MEETING NOTES from
Virginia LiDAR Needs Assessment
Federal Agency / State Agency LIDAR "interest group" meeting
August 16, 2007
10:00 AM – 2:30 PM

Purpose: "To identify and assess the needs of the Commonwealth of Virginia for a statewide or regional LIDAR survey and to explore mechanisms for its implementation and funding"

On August 16, 2007, the DMME-Division of Mineral Resources hosted the meeting at their office in Charlottesville. Dan Widner (VGIN) and Diane Eldridge (USGS) were the moderators. Approximately 37 people from various state and federal agencies attended.

Welcome and Introductions

Dan Widner opened the meeting with a few introductory remarks outlining the purpose of the meeting and the agenda. He went on to mention that VGIN is in the planning stages for a 2009 data collecting (orthoimagery) flight. Dewberry has been hired to help with the pre-planning of the 2009 flight. LiDAR costs are coming down and it might be possible to include LiDAR in the 2009 flight.

Dan Widner offered to make the powerpoint files (*) used in talks given by Brian Mayfield (Dewberry), Peter Chirico (USGS), Ed Erb (VDMR), Mike Zmuda (VDOT), Jim Mauck (USGS) and Dan Widner (VGIN) available for download from VGIN website. Consequently, only a brief summary of these talks will be included here.

LiDAR Technology Review

Brian Mayfield and Timothy Black, representatives from Dewberry, reviewed current LiDAR technology. LiDAR is a direct measurement of terrain using the active sensing technique of emitting a beam of light and measuring the timing and amount of light bounced off the terrain and returning to the measuring devise. This produces a “point cloud” where each point is classified by the order of its return to the receiver. The raw point cloud is a very large dataset that requires further processing to be useful. While the point cloud would be a deliverable from any LiDAR project, it would likely be useful only to sophisticated users. Products produced from the LiDAR are more likely desired by most users.

While LiDAR cannot be collected in rain or fog and must be flown below clouds; it can be flown day or night. LiDAR can be flown with digital photography but it adds to the cost of the LiDAR because digital photography can only be captured during the daylight and it has a different footprint and flight requirements than LiDAR. Depending on the collection platform, it may not be possible to perform both types of collection at the same time because the camera and the LiDAR equipment may use the same scan port in the fuselage.

Intensity Imaging is an additional LiDAR product that measures the total amount of light returning. It can be used for stereo-compilation to generate 3D breaklines (LIDARgrammetry) to control contours generated from bare-earth LiDAR elevations. It is better than using breaklines generated from photography because of a disconnect between photography and LiDAR.

There are two standards for LiDAR collection: FEMA (Guidelines and Specifications for Flood Hazard Mapping Partners) and NDEP (Guidelines for Digital Elevation Data). The two differ in how error is calculated. Dewberry prefers to use the NDEP standard.

The cost of LiDAR ranges from @ \$375/ mi^2 for a large project area to @ \$700/ mi^2 for a smaller project area. This price is for collection only and would not include breaklines, contours or other derived products.

Questions:
Edge-matching at state borders?

Dewberry recommends requiring a tighter spec on the borders with a significant buffer area, and requiring the contractors to deliver not only the data but also the trajectory path and the raw data.

What are the issues with flying photography and LiDAR at the same time?

- Limits LiDAR flights – can't fly at night, for instance
- Sun angle, fog, and daylight are all constraints for phtography that don't affect LiDAR
- Increases the cost of LiDAR capture
- Optimal flight altitude is different: 7500/1000 feet for LiDAR and 10,000 feet for photography
- Generally use different planes for flying LiDAR or photography
- Want LiDAR flight paths to be less than 30 km from bay stations

Optimal post spacing?

2 meter post spacing ~ 2 ft contours - ask for 1 meter post spacing

Flat terrain may need more accuracy and higher post density (4-6 points/ square meter) than more hilly terrain.

A comparison of LiDAR derived elevation to photogrammetrically derived elevation

Peter Chirico (USGS –Geology Discipline) compared techniques for deriving elevation data. He said that it is not always possible or cost-effective to fly LiDAR. He showed DEMs created from LiDAR, photogrammetrically created contours, autocorrelated aerial photography, and DTMs created to orthorectify aerial photography. The first two compared very favorably with the DEM from photogrammetrically created contours being a little smoother than the DEM from LiDAR. The DEM from autocorrelated aerial photography was slightly noisier than the first two methods but was very much cheaper to collect. The DTM data was inadequate and simplified the slopes too much.

Where there was high-resolution aerial photography, it might be more cost-effective to create contours photogrammetrically. The point was made that contours can be produced in other ways at a much reduced cost. The real value of LiDAR is:

1. The delivery of a surface instead of an abstracted contour.
2. Several types of features and details are much more readily apparent on the LiDAR surface rather that a contour layer.

Accuracy is dependent on where the control point is. For geologic uses, the relevant error was on the slopes. He felt +/- 1 to 3 meters was reasonable.

The method used to process the LiDAR was extremely important. Artifacts left in the data after processing were hard to remove and affected derivative maps.

Presentations and Discussions on Needs and Benefits of a LIDAR survey
– ***State agencies***

Ed Erb (VDMR) described the need for up-to-date elevation data and topographic maps.

Elevation data is fundamental to geologic mapping. Topographic maps are used as a base for geologic maps.
VDMR's criteria for ideal elevation data include: bare-earth digital elevation data; high resolution; scalable; ability to generate contours to USGS standards; can reacquire periodically for monitoring change; defines detailed features on steep slopes; detects holes, pits, and local subsidence; and detects faults and other linear trends.

Prior to the 1990's, VDMR had the responsibility for coordinating the creation of topographic maps in Virginia. A joint VDMR/USGS project from 1962-72 expanded VA's topo coverage from 10% to 100%. Post-1972 updates of topo maps have focused largely on cultural changes, with minimal to no updating of the actual contour lines. Consequently, VDMR has been relying on a rapidly aging and out-of-date set of topo maps. Many of the contours in Southwest Virginia have not been updated since the 1950's. In addition, many of the Southwest Virginia topos were created by the TVA at less than USGS standards. Much mining has occurred since the 1950's. Existing topographic maps are consequently hard to use.

DMR applications for detailed digital elevation data focus on geohazards, mineral resource studies, and geologic mapping.

Landslides and debris flows resulting from hurricanes and other major storms have historically caused serious loss of lives and property in VA. The potential for increasing storm intensity related to warming of sea-surface temperatures is a heads-up for VA to prepare for similar disasters in the future. Highlighting the probability of occurrence of landslides and debris flows throughout the state requires accurate and detailed elevation data, especially for mountainous terrain with steep slopes.

North Carolina has faced similar storm-related disasters in mountainous terrains. They responded by initiating a Landslide Hazards Program coordinated by the North Carolina Geological Survey that included the creation of a series of digital county maps to enable communities to evaluate and reduce the risks of building homes and other structures in landslide-prone areas. Virginia should support a similar program within VDMR.

Other geohazard-related topics include those related to current and past mining activities and karst-related sinkholes.

Mineral resource studies require accurate surface elevations for a variety of applications, including locations of coal outcrop lines; locations of surface mines; reclamation of abandoned mine lands; surface topography for 3D modeling of the Southwest Virginia coalfield; assisting in planning for horizontal drilling for coalbed methane and unconventional gas targets; improved mine rescue planning; and assessment of mineral trends and controls of mineral occurrences.

Geologic Mapping benefits from accurate surface elevation data in many ways, including identification and location of contacts, faults, and other surface features; differentiation between surface and bedrock geology, mapping of geologic framework essential for groundwater characterization studies; review of environmental impact statements, and coastal erosion and beach re-nourishment studies.

LiDAR must be viewed as one tool but should be seriously considered in high priority areas, along the Blue Ridge, in the Southwest, in the ShenandoahValley and Blue Ridge karst areas. A pilot test in one of the above areas may be appropriate.

Summary of VDMR's interest in accurate digital elevation data:

- Seeking an optimal mix of available tools and processes that will provide elevation data at an appropriate level of scientific accuracy and cost effectiveness to fulfill our mission. LIDAR is one of those tools.
- While VDMR's responsibilities are statewide, our highest priorities for elevation data are in the Blue Ridge Mtns, Southwest Virginia coalfield, and the Valley and Ridge karst terrains.
- Accurate elevation data, including LIDAR, should be acquired statewide as soon as possible.
- VDMR, would encourage possible pilot tests in one or more of the priority areas indicated above.

Coastal Zone Discussion
Marcia Berman - VIMS
State Wetland Watch – monitor wetlands over the long term, measuring loss of wetlands due to water level rise. Need to develop solution to predict long-term survival of ecosystems.
Can model inundation due to hurricanes, tsunamis, and sea level rise; but can't do it without current detailed elevation data.

Feel the flat land has greater need for LiDAR than steep areas because there is so little elevation that the high accuracy is essential. Don't think aerial photography will work.

Need elevation to assess sediment input of riparian and coastal area. Need accurate elevation along shoreline.

Scott Lerberg - VIMS
The four reserve site are being proposed to be used as reference sites to study many issues include sea level rise and salinity.

They have high-resolution photography but no LiDAR. Good elevation data is needed to do inundation modeling. Want to do hydrologic modeling for York River.

Is bathymetric LiDAR possible?

- Three or four times as expensive as regular LiDAR
- Turbidity is an issue
- Army bathymetry LiDAR better than EROL
- Four band imaging is useful

Shep Moon (DEQ)

The goal of **Coastal Zone Management** is to help their partners (state agencies, localities, and PDC's) to mangage coastal resources. They have the ability to make data available over the internet and to fund some studies.

DEQ's Coastal GEMS (http://www.deq.virginia.gov/coastal/coastalgems.html) is an internet site providing a "gateway to Virginia's coastal resource data and maps; coastal laws and policies; facts on coastal resource values; and direct links to agencies responsible for current data."

Wetland watch – the Governor of Virginia wanted to know why Maryland and North Carolina have data but Virginia doesn't.

General discussion:

Canopy information is important to Forestry et. al.
All data, regardless of current need should be delivered to the client.

*** Mike Zmuda (VDOT)** presented arguments in favor of maintaining and upgrading Virginia's geodetic infrastructure. In 2000, Virginia had 187 HARN stations, approximately half had elevation. Since 2000, many of the stations have been lost due to construction.

North Carolina has put in a excellent statewide system of permanent GPS bay stations with real-time network feed (CORS). He recommends that Virginia follow North Carolina's example. We lag behind most other Atlantic states in regards to geodetic network implementation.

Permanent stations facilitate change detection and reduce the cost of statewide data collection.

Mike cautions that success depends on partnering with both localities and the private sector.

VDOT has a high resolution elevation need statewide.
Need to incorporate the survey aspect into this project. Must be done at the planning stage.
QA/QC needs to be funded BEFORE the project gets on the road.
CORS stations may need evaluation.
Terrestrial scanner works in concert with LiDAR for VDOT needs.

Comments

VDEM - The mitigation for Hurricane Isabel alone totaled more than $2 billion. That is a lot more than the cost of LiDAR.

Presentations and Discussions on Needs and Benefits of a LIDAR survey – Federal agencies

USGS

Jim Mauck representing **Geospatial Information Office.**

Provide base data for *The National Map*.
Drivers: Emergency Response and Homeland Security. The Emergency Response is focused along the coast.

The new USGS director is keen on resurrecting the topographic maps programs as Map-on-Demand PDFs. He supports creating elevation data sufficient to create 2-ft contour in counties along the coast (current priority; mission includes data for the entire nation). He is also interested in make maps in support of national science priorities.

FY08 focus is on the Gulf and southern states (including Virginia), along the Mexican border, and science priorities.
FY09 focus is on the Northeastern and western states, along the Canadian border, and science priorities.

Need to leverage their money wherever possible.
Partnering with NGA to get LiDAR in the Urban Areas. In Virginia that includes Richmond, Norfolk, Williamsburg, and Northern Virginia.

Virginia NED is poor; mostly 10 meter data from 30 meter. Tagged Vector Contours (TVCs) are being created in the piedmont area.

Recommended CLICK as a repository for raw LiDAR data clouds.

Pete Chirico representing **Geology** had no further comments

Tom Cecere representing **Geography**: "Our needs are your needs."

It may be a single technology or it maybe a combination of technologies that serves us best in getting cost-effective elevation data.

Satellite data is another possibility

Change is constant

Not one solution
- Metadata is critical
- Need to know the limitations of the data

Identify areas of interest and make sure they are taken into consideration in the specifications. Accuracy is in the eye of the beholder.

Mark Bennett of **Water Resources Discipline** sent written comments.

"There are a number of potential uses that we have discussed in the office:
Stream cross-sections – there are a number of studies that we have discussed with state agencies where being able to get elevations for stream cross-sections would have great utility. Obviously, these cross-sections would not be as accurate as what we get when we survey in the field, but field surveys are very expensive and there are only so many that you can do. Some applications are: surface water modeling, flood plain modeling, erosion estimates from urban stream corridors, and real-time flood inundation mapping.

Sink hole identification and identification of linear geologic features. Both of these are important in terms of geologic mapping, but also in trying to understand regional flow systems.

More accurate elevation data for a variety of applications including modeling, determining slopes, and delineating watershed boundaries.

The consensus is that once this data was available on a statewide basis, there would be no shortage of applications from our perspective."

Kirk Waters (NOAA)

Uses of LiDAR:
For NOAA use

- Hurricane evacuation calculations and planning
- Shoreline
- Obstruction to flight path

In cooperation with other partners

- Tsunami modeling
- Marsh retreat/ Coastal zone management
- FEMA Flood plain mapping

Requirements:

- Bare-earth
- Want all returns
- Need to be able to do change analysis. Highly recommend permanent control points.

Interested in elevation up to 30-ft contour. Will collect data for the entire county if the 30-ft contour falls across the middle of the county. Most interested in coastal areas. Up to two counties in from shoreline.

Need to frame this in Cost/Benefit terms. Example, Ohio DOT saved 1-3% of the cost of the project by using LiDAR in the planning of the project.

FEMA sent written comments that Diane Eldridge provided.

FEMA is not in the business of collecting elevation data. They are directed to use the best available data.

Discussion:

Virginia is in Region 3. Very little FEMA money is spent in Region 3 on data collection efforts.

Virginia is already in 4th year of FEMA map modernization. Little late to do anything about LiDAR; money is pretty much spent. Might be able to do something in Phase 2 of FEMA map modernization.

Comments

What do localities have?

- 50 localities have paid for 2-ft or 4-ft contours to be made from 06/07 VBMP photography.
- Some high population areas already have LiDAR/detailed elevation data

Might be cheaper to get contours made (from current VBMP photography) for all counties than fly LiDAR.

Is partnering with private industry, like insurance and power companies, possible?

Bill Slocumb of the **National Park Service** sent written comments that Diane Eldridge provided.

"The NPS would be very interested in LiDAR data for several reasons:

1. A better DEM than is currently available. USGS seamless has 10 and 30 meter DEMs, but the parks would like something with a smaller spatial resolution because the units are usually rather small and the 10 and 30 meter products aren't the best for them. This relates to most of the applications below.
2. A high resolution DME would be great if the parks decide to produce some new orthorectified imagery. Several years ago, we (NC State) were contracted with the parks to create ~1' spatial resolution orthorectified imagery. Sometimes we could only get 30 meter DEMs that can cause some displacement and distortion.
3. A lot of the NPS units in Virginia are cultural in nature and have earthworks and trenches located in and around the park. LiDAR could help resource managers locate potential sites that have not been discovered, I would hope…
4. We work with the Northeast Region Fire program and use elevation data as an input to model fire behavior, e.g. it could assist with canopy cover, height to live crown, and stand height. LiDAR would be better than standard products (relating back to #1 above).

5. Hydrologic/wetland modeling (We've done some of this and the standard elevation data, even 10m resolution, doesn't yield the results you would expect).
6. Change detection (biomass loss, forest/ ag to urban, the list could go on…)
7. It would be interesting if habitat/vegetation stratification could be modeled using LiDAR. That's a good potential research question that hasn't been investigated much.
8. Trail and road profiles"

Fred Garst (USDA-NRCS)
Three key areas LiDAR is useful:

- Soil Survey
- Conservation
  - Wetland restoration
  - Agricultural waste management
- Dam Rehabilitation /Flood Restoration

Need to calculate Peak Discharge.

Dam breach and inundation is a high hazard. Need tighter specifications for Dam Inundation modeling than the FEMA specifications. Want the data to work well in forested areas and in flat areas.

Comments
Dewberry – On 20% grade +/- 30 cm vertical is reasonable

The missions of the federal agencies are many and diverse. Some applications require updated and higher resolution elevation data that could be derived from a number of sources / tools. Other applications require the surface portrayal (derived form multiple returns as well as bare earth) offered by LIDAR.

Diane said that they were just beginning to collect the needs of federal agencies for elevation data in Virginia.

Neighboring States approach to LiDAR Collection: Funding Models, Specifications and Collection Cycles

Dan Widner presented information on statewide LiDAR collection programs in Pennsylvania, North Carolina, Maryland, and South Carolina. **Pennsylvania** is in the middle of a 3-year collection program costing $7.5 million. They are in general following the FEMA guidelines with 1.4-meter data posting. They are requesting the data be delivered in LAS standard format with 7 or 8 classifications.

North Carolina worked with FEMA to collect LiDAR in the wake of several devastating hurricanes. The state has paid $23.2 million. It is estimated that FEMA paid 40% of the total cost

but the actual dollar amount is unknown. The LiDAR was supplemented by field data collection along streams. The LiDAR data was collected using 3.5-meter posting. It was mention in the discussion that North Carolina's experience in collecting LiDAR contributed to the FEMA LiDAR standard and that were North Carolina to collect the data today, they might do things a little differently.

LiDAR collection in **Maryland** is being done on a county-by-county basis. The Maryland DNR is coordinating the effort and is contributing some money but it is not able to dictate standards to the counties. Some of the counties will not share the data that they collected. In general, the data are collected using FEMA specifications – leaf-off with no snow or flood. They are going for elevation data. The deliverables are first and last return, intensity, and 2-meter DEM.

South Carolina is working on a collaborative agreement with a multitude of federal agencies (NOAA, FEMA, USGS) State agencies and localities Once the data is collected it, a number of resources will be tapped to process the data and produce the desired derivative products. A collaboration of State universities may assist with this effort.

Discussion

Geodetic System with static control points – very important.

Are there Cost/Benefits Analyses that can be obtained from other states?

What can LiDAR do that 2-foot contours can't?

We should have a pilot project comparing LiDAR and 2-foot contours

Many dense population areas are already looking at obtaining or have obtained LiDAR

Dewberry says that the costs break down to 50% collecting and 50% processing

Chirico says that costs also including computing power (ie PC's), software, and storage.
Processing is very important.
Need to get raw data cloud as deliverable. Can storage raw data cloud with **CLICK**.

Action Items

- Continue talks online
- Need to get local needs
    - survey localities need
    - may be a meeting
    - inventory existing elevation data available at localities

- Should consider partnering with locals that already are collecting LiDAR
- VGIN will post online LiDAR/elevation requirement summarized from this meeting and meetings with localities.
- Develop a Plan of Action
- Funding
  - Need to put together a Cost/Benefit Analysis for presentation to the legislature
- Support development of CORS and geodetic benchmark network similar to North Carolina's
- Evaluate how LiDAR fits into the VBMP

Attendees
Dan Widner – VGIN
Ed Erb – DMME/DMR
Stu Blankenship – VGIN
Tim Blak – Dewberry
Brian Mayfield – Dewberry
Kirk Waters – NOAA
Tom Cecere – USGS
Elizabeth Campbell – DMME/DMR
Scott Lerberg – VIMS
Shep Moon – DEQ
Amy Gilmer – DMME/DMR
Chris Kinkade – NOAA
Marcia Berman – VIMS
Trent Park – VEDP
David Gunn – DCR/Floodplain
Lyle Hornbaker – VGIN
John Aaron – VDOT
Stacey Roosa – VDOT
Jim Pugh – VDOF
Matt Heller – DMME/DMR
William Lassetter – DMME/DMR
Michael Zmuda – VDOT
Fred Garst – USDA/NRCS
Wade Biddix – USDA/NRCS
Jim Mauch – USGS/NGP
Diane Eldridge – USGS
Mike Warner – USGS
Pete Chirico – USGS
Brian Crumpler - VDEM